



Energy+Environmental Economics

Electric industry trends + and their impacts on hydropower

*Bonneville Power Administration Strategic
Plan Implementation Public Workshop*

Portland, Oregon

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Arne Olson, Senior Partner



+ **Broad changes are sweeping through society that will have lasting impacts on the electricity sector**

1. **“Technology”**: Technological change in data processing, communications and manufacture are making new technologies available and cost-effective
2. **“Policy”**: Climate change and the need to decarbonize our economy will require the development of massive quantities of low-carbon electricity
3. **“Democracy”**: Consumers are increasingly wishing to take control of their own destiny, decentralizing the locus of decision-making

+ **The role of hydropower will be more important than ever, but monetizing hydro’s real value is continually challenging**



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“Technology”

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SINGLE-STATOR WATTHOUR METER

TYPE AB1 S.

200 CL 240 V 3 W 60 Hz TA 30

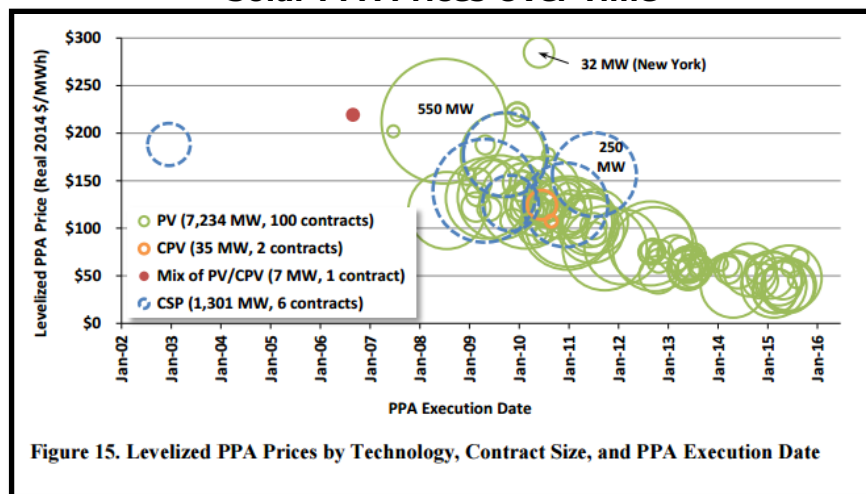
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Renewables

- + Solar PV costs have declined tremendously in the last decade
- + Wind and solar are now cost-competitive with conventional resources in many markets —even without subsidies!
- + Rooftop solar can be installed at below the embedded cost rate in some jurisdictions

Solar PPA Prices Over Time



Source: [Utility Scale Solar 2014](#) (LBNL, 2014)





Energy storage

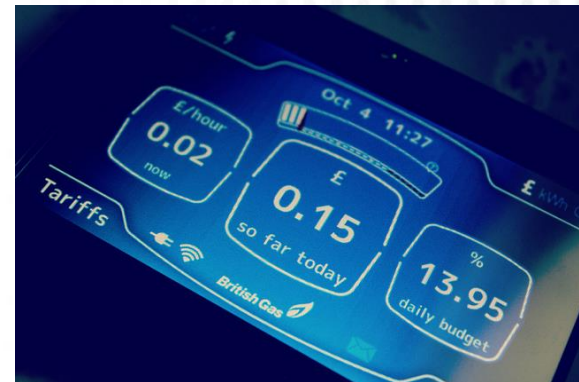
- + There is increasing interest in grid-connected energy storage for renewable integration and investment deferral
- + Battery costs are declining rapidly with manufacturing scale-up and technology advances
- + Lithium-ion appears to be following the photovoltaic path





IT and communications

- + **Smart devices and advanced communications networks provide new mechanisms to facilitate customer response**
- + **Improved access to data and control systems will enable response to occur seamlessly and with little effect on consumer experience**
- + **IT is driving efficiency improvements at utilities**
 - The Energy Imbalance Market has been a big driver of IT investments





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“Policy”

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Deep reductions in greenhouse gas emissions are called for globally

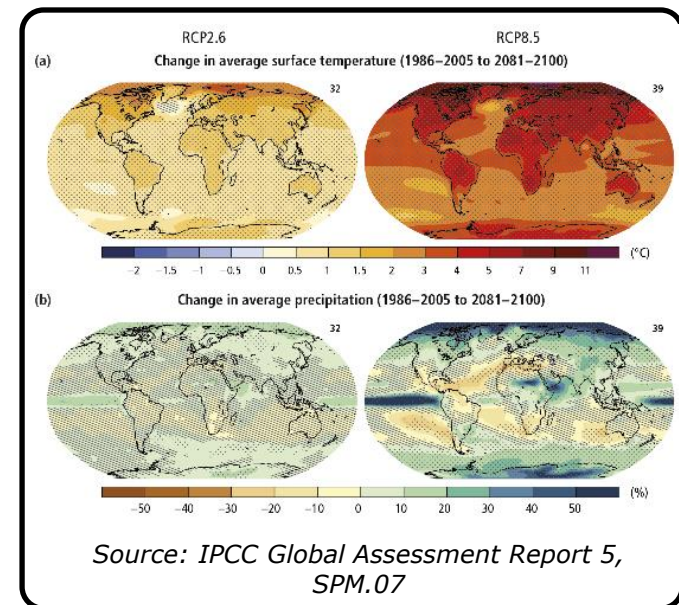
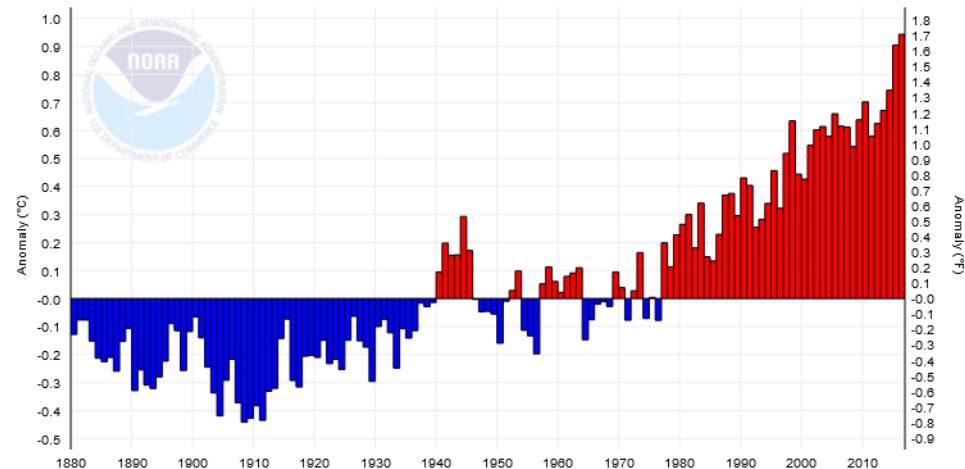
+ The 2016 Paris agreement committed industrialized nations to 80% reductions below 1990 levels by 2050

- Roughly consistent with IPCC/UNFCCC goal of keeping global average temperature rise within 2°C to avert catastrophic climate change

+ If current trends continue, 2°C aggregate warming will be exceeded

Source: NOAA, <https://www.ncdc.noaa.gov/monitoring-references/faq/indicators.php> Global annual average temperature measured over land and oceans. Red bars indicate temperatures above and blue bars indicate temperatures below the 1901-2000 average temperature.

Global Land and Ocean Temperature Anomalies, January-December

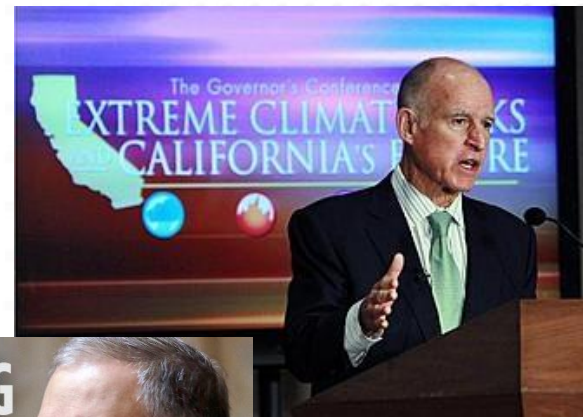




State policy is the major driver of clean energy investment

+ California:

- SB 350 (2015): 50% RPS by 2030
- SB 32 (2016): economy-wide GHG reduction of 40% below 1990 levels
- Net Energy Metering 2.0 decision
- SB 100 introduced: 100% RPS by 2045



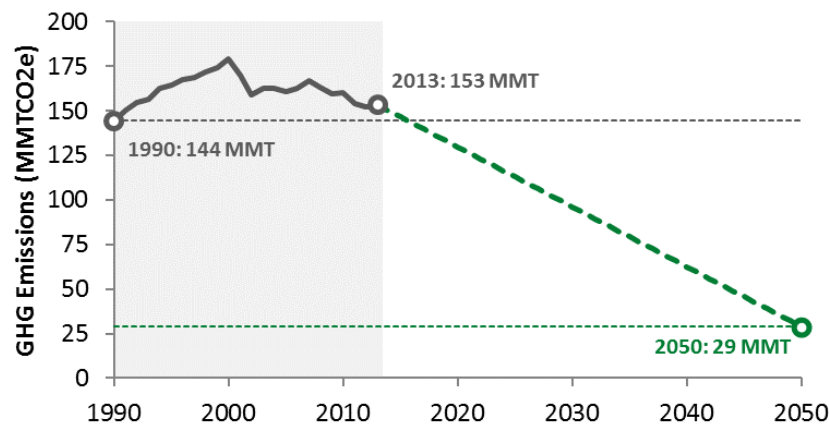
+ Washington

- 15% RPS by 2020
- Carbon tax and 100% Clean Energy bills being considered

+ Oregon

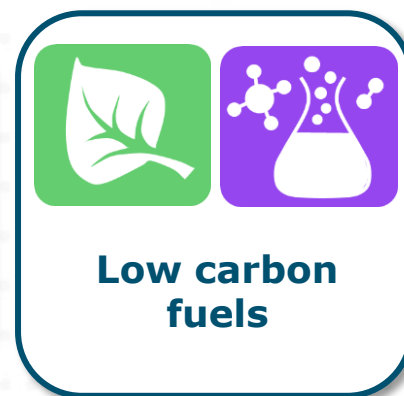
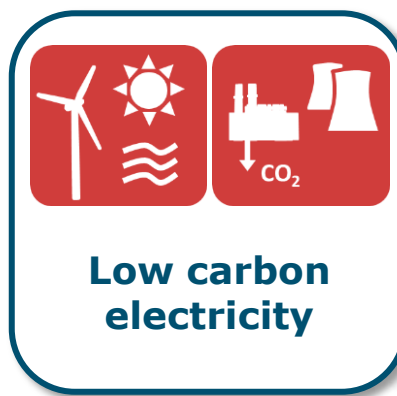
- 50% RPS by 2040, no coal by 2030
- Cap-and-trade bill being considered

Historical and Projected GHG Emissions for OR and WA





Four “pillars” of decarbonization are needed to meet long-term GHG reduction goals

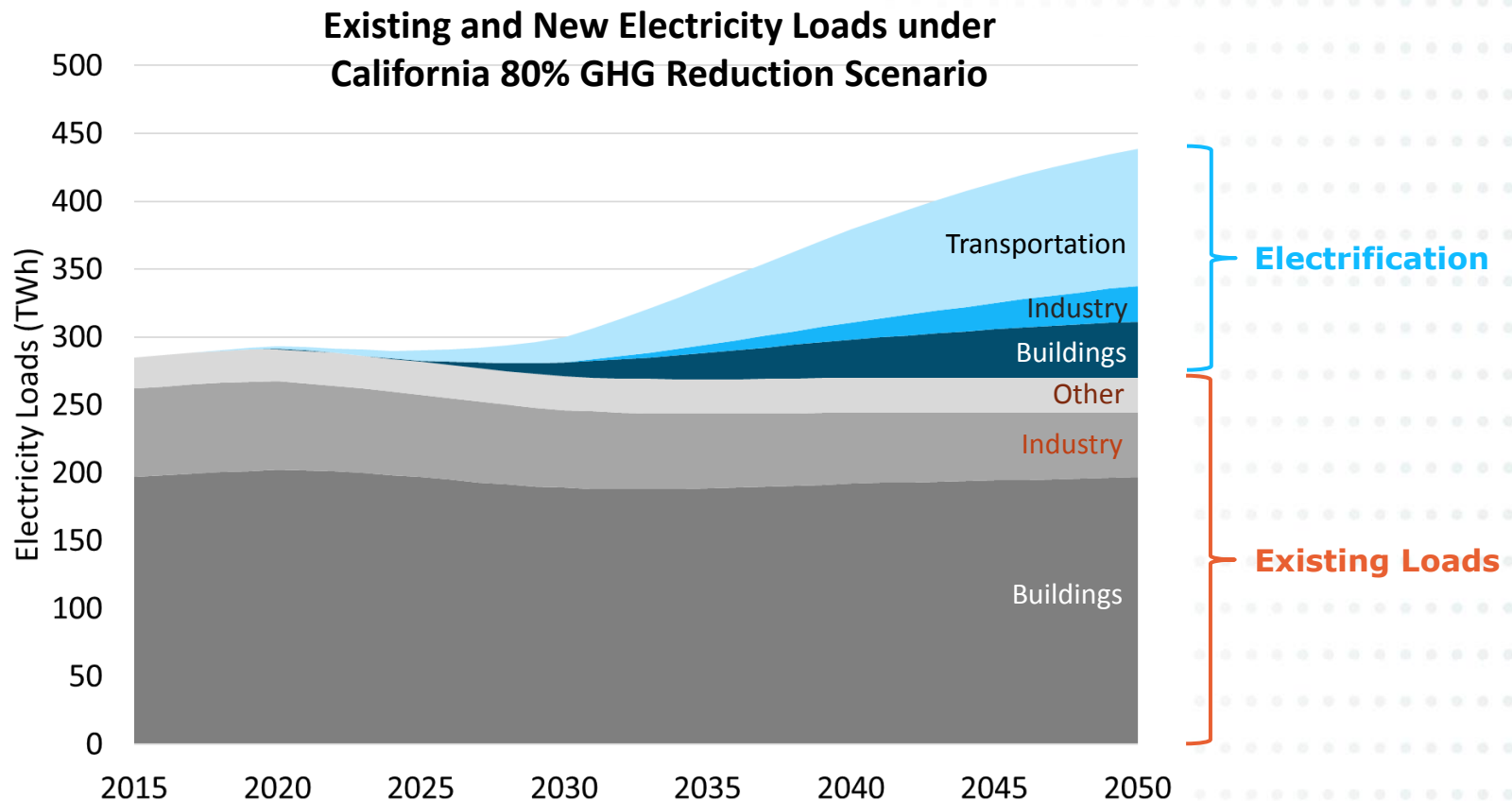


- + Four foundational elements are consistently identified in studies of strategies to meet deep decarbonization goals**
- + Across most decarbonization studies, electricity plays a key role in meeting goals**
 - Through direct carbon reductions
 - Through electrification of loads to reduce emissions in other sectors



Electrification will result in significantly higher electric loads (California example)

- + Electrification of transportation, buildings and industry aids in decarbonization of the California economy
- + Electric load may increase by 50% relative to Current Policy





Low-Carbon electricity generation must become the primary fuel for the entire economy

1. Renewable

- Hydroelectric: *flexible low-carbon resource in the Northwest that can help to balance wind and solar power*
- Wind: *high quality resources in West, particularly East of the Rockies, intermittent availability*
- Solar: *high quality resources across the West, intermittent availability*
- Geothermal: *resource limited*
- Biomass: *resource limited*

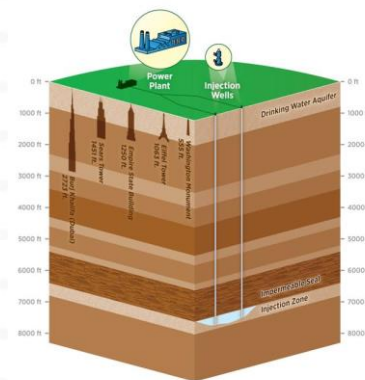


2. Nuclear

- Conventional: *baseload low-carbon resource*
- Small modular reactors: *potentially flexible low-carbon resource*



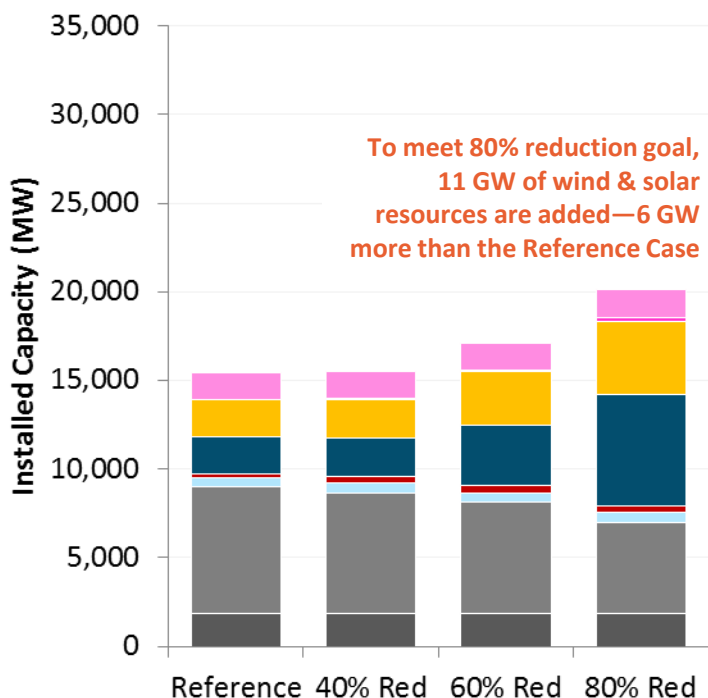
3. Fossil generation with carbon capture and storage (CCS)





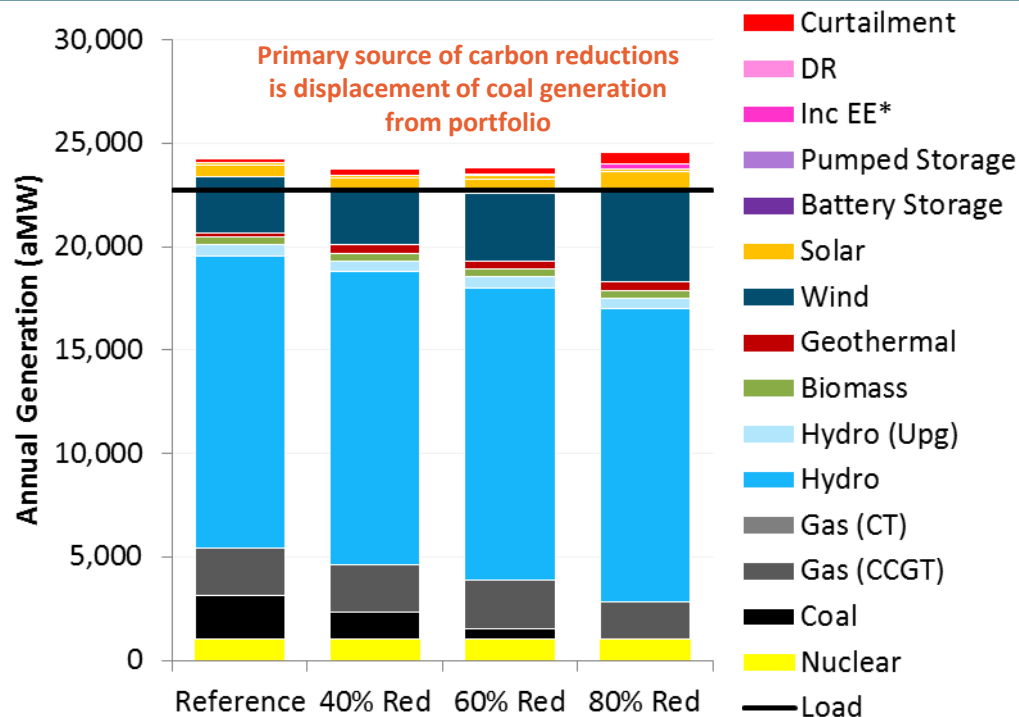
Northwest achieves 80% reductions (electric sector only) by replacing coal with a mix of EE, renewables and gas

New Resources Added by 2050 (MW)



- + 11,000 MW of new wind and solar power are added by 2050
- + 7,000 MW of new natural gas generation needed for reliability

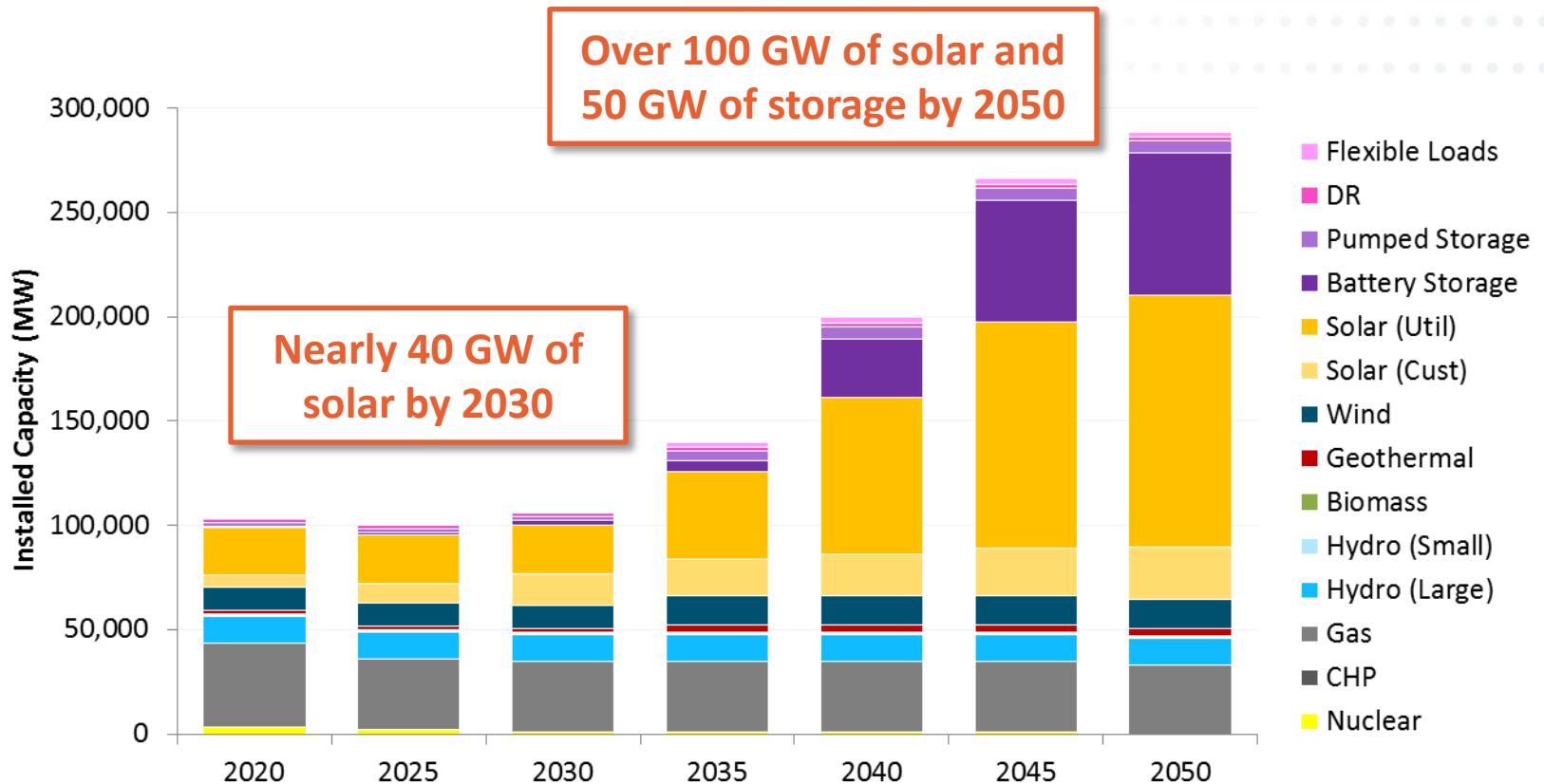
Annual Energy Production in 2050 (aMW)



- + Hydro generation still dominates
- + Wind and solar generation replace coal
- + Meets carbon goal at relatively low cost



California's 2050 strategy involves mostly solar and storage

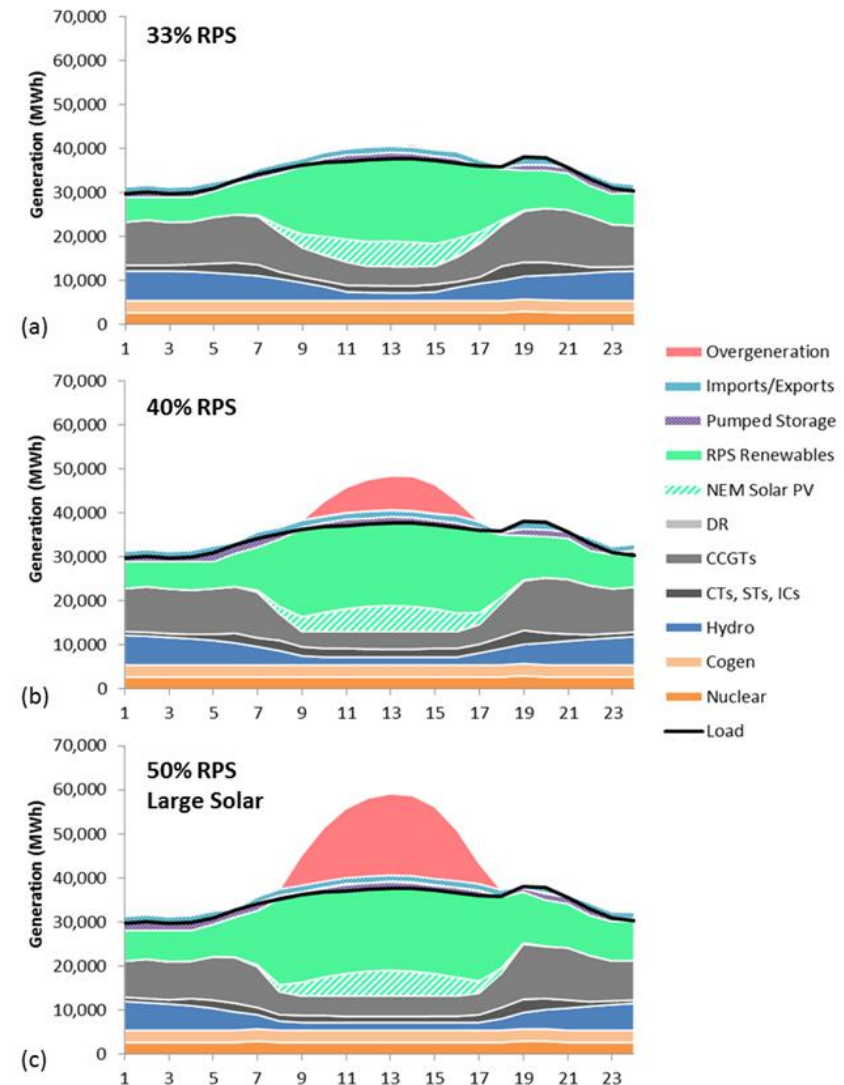
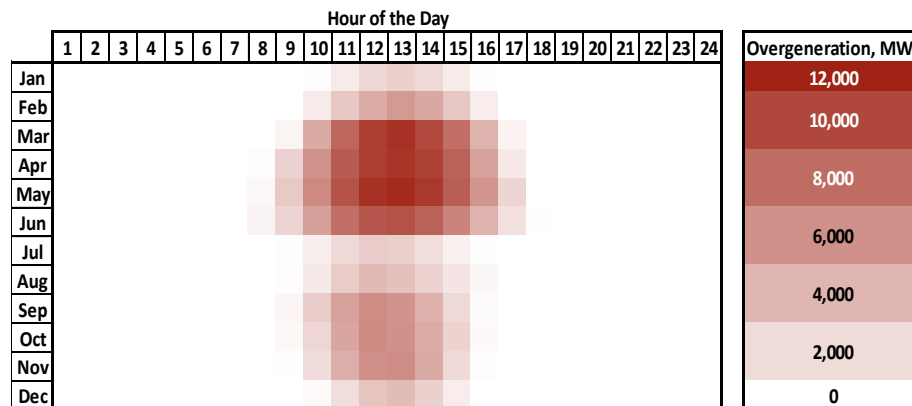


+ Electric sector reduces emissions to 20 MMT by 2050 while serving much higher loads from electrification of transportation, buildings and industry



High renewable penetration will result in frequent periods of oversupply

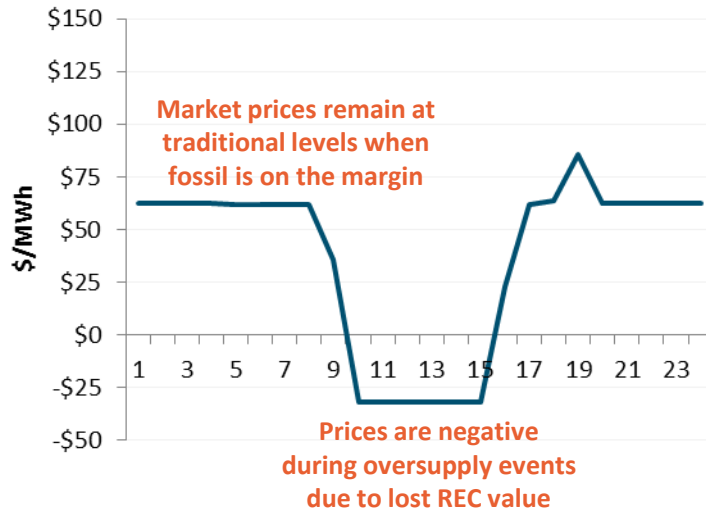
- + The consequence of insufficient load or dispatch flexibility is renewable curtailment
- + Curtailment is small at 33% RPS but increases dramatically above 40%
- + E3 simulations show overgen, and negative pricing, in up to 20% of hours by 2030





RPS policies create market distortions that devalue other zero-carbon resources

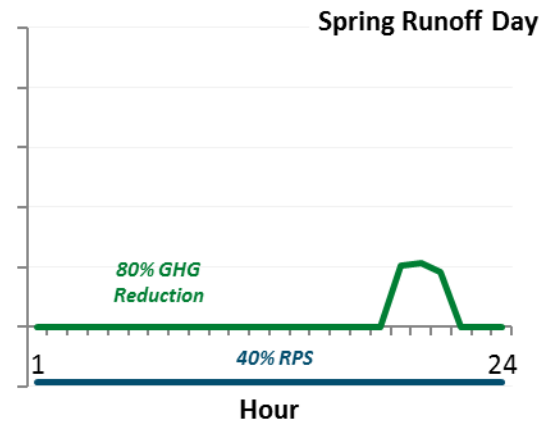
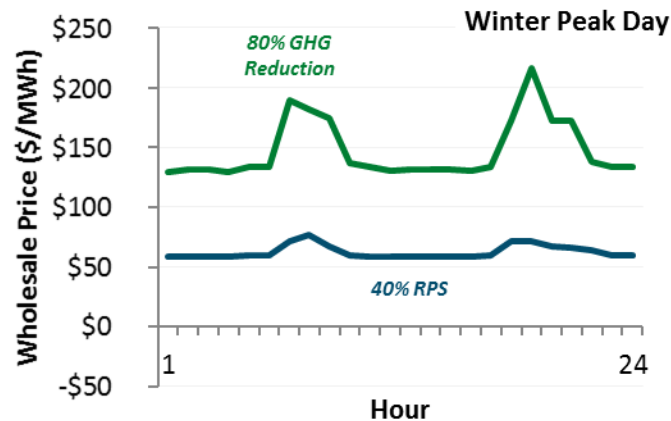
Daily Energy Price Profile under High RPS – California



Daily Energy Price Profile under low GHG Cap – California



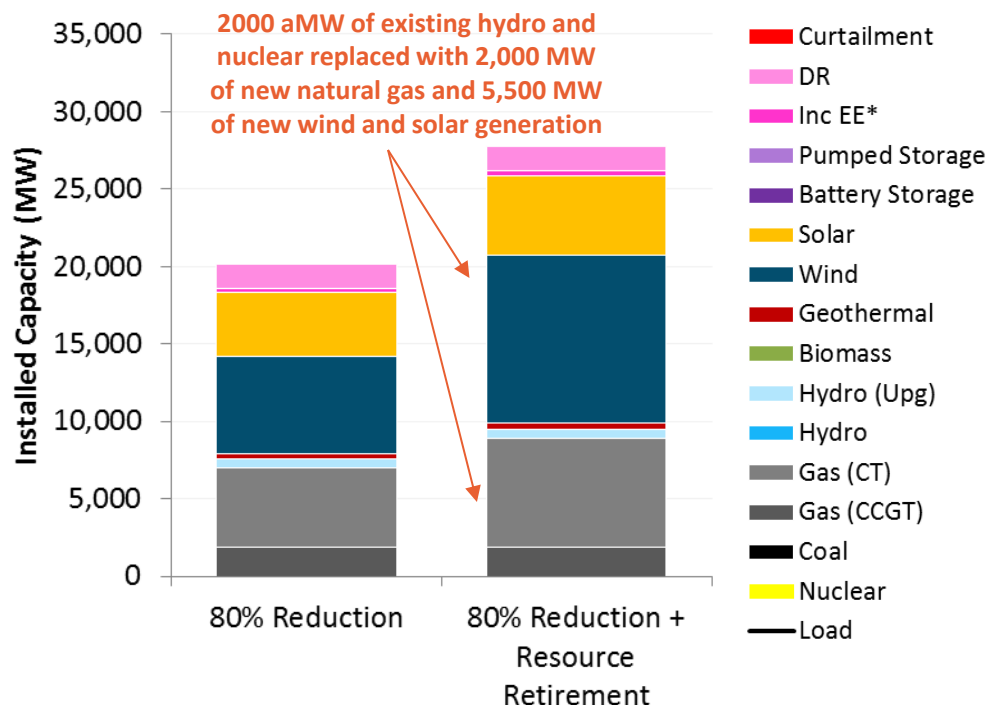
Similar phenomenon happens in the NW





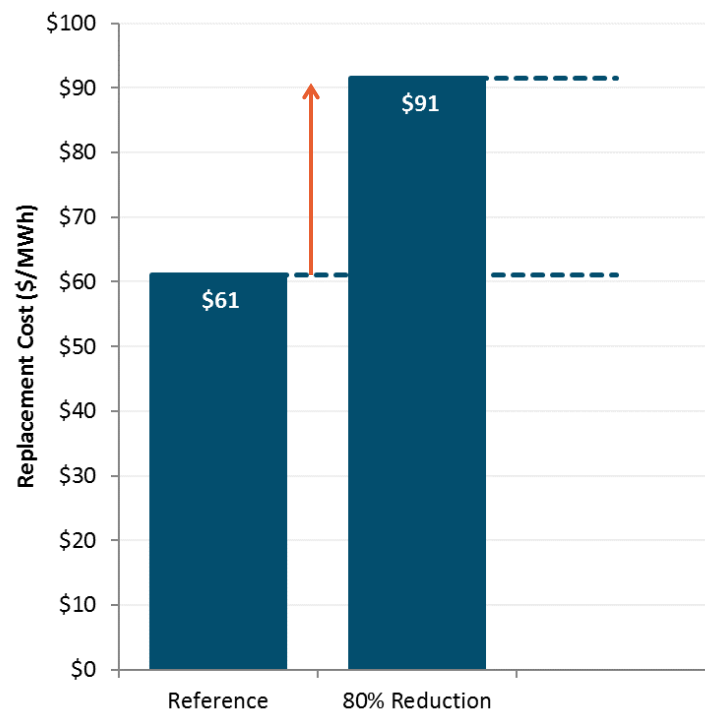
Existing zero-carbon resources are really valuable under a deep GHG reduction scenario

80% Carbon Reduction Case with Retirement



- + 2,000 aMW of existing resources replaced with 7,500 MW of new wind, solar and gas
- + Total cost of meeting carbon goal increases from \$1B to \$2.6B per year by 2050

Cost of Replacement Power

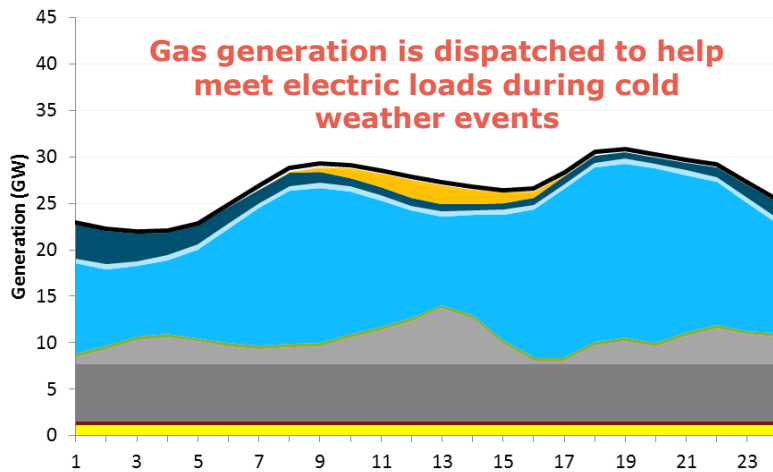


- + Cost of replacement power is over \$90/MWh in 80% Reduction case
- + Hydro is valued for capacity, flexibility and zero-carbon energy

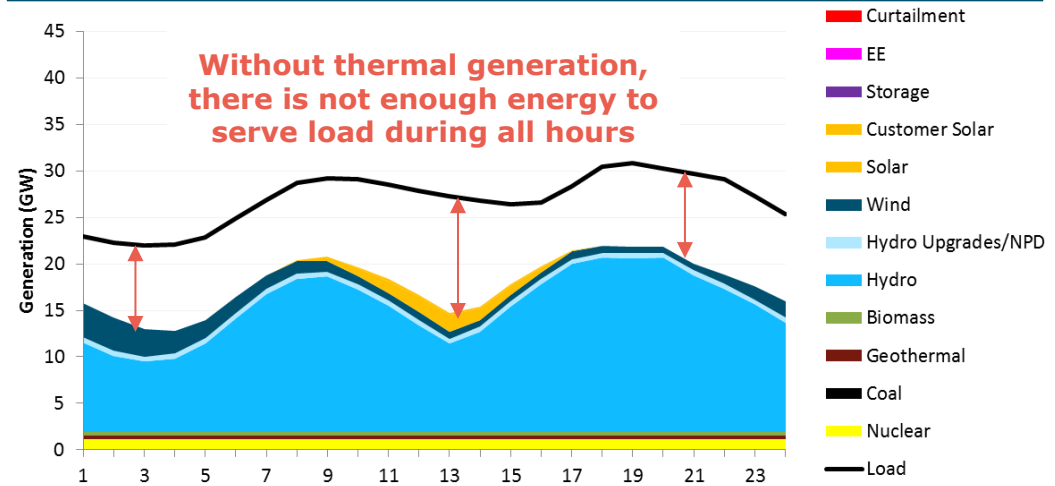


Natural gas generation will still be needed for reliability and is a good complement to hydro/wind/solar

Cold Winter Day under 80% Reduction

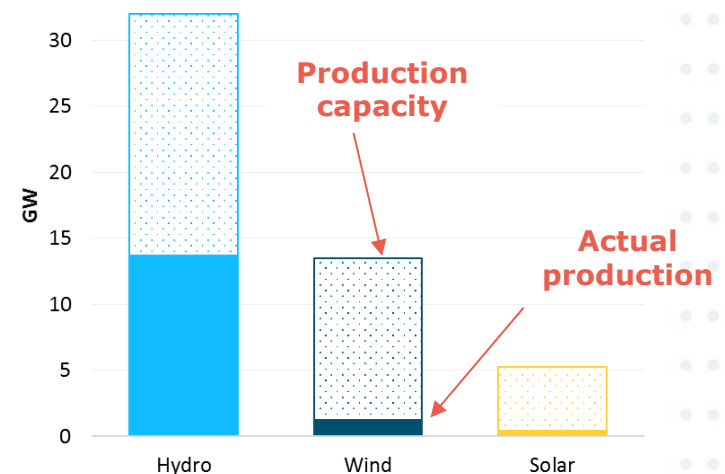


Cold Winter Day Without Gas



- + Most challenging conditions for the Northwest power system are multi-day cold snaps that occur during drought years
- + Wind and solar production tends to be very low during these conditions
- + Absent a technology breakthrough, gas generation appears to be needed for reliability

Energy from Zero-Carbon Resources





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Consumer empowerment is resulting in a decentralization of decision-making

- + **Restructuring of the electric utility industry in the 1990s invited new entities into the industry**
 - Direct access (DA), electric service providers (ESPs), independent system operators (ISOs)
- + **Municipalization and community-choice aggregation (CCA) allow local control of energy decisions**
- + **Rooftop solar and demand response empower small customers**
- + **More difficult to justify large, centralized infrastructure investments**





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Thank You!

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